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Summaries of Biomass Energy Projects
Funded by
The Department of Natural Resources and Conservation

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MONTANA BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

INDUSTRY INVESTIGATES WOOD AND COAL FUEL TO REPLACE OIL

A new study shows that the use of wood waste as a clean and economical industrial fuel is getting more attractive outside the wood products industry. Wood-waste fuel has long been commonplace in the processing of wood products, but other industries have been slow to recognize its advantages.

The study, coordinated by Rayson Brothers Logging Company, of Libby, Montana, was funded by the Montana Department of Natural Resources and Conservation, Rayson Brothers, and the Bonneville Power Administration. The intent of the study was to determine whether local wood waste could replace all or part of the fuel oil used at the W. R. Grace vermiculite dryer, which is a major portion of the plant's energy consumption. At the present delivered rate of 66.4 cents per gallon, the No. 5 fuel oil used in the dryer at operation costs $587,000 annually. Hog fuel produced from wood waste could supply the same amount of energy for $114,000, according to the study. This would require 12,000 tons of wood waste per year, at an average cost of $9.50 per ton.

It was determined, however, that coal could be provided more cheaply, at least at the outset. This was the result of a unique situation, with large quantities of low sulfur coal available from several Canadian coal mines located within 120 miles of the Grace plant.

Nevertheless, the study indicates that wood would be the most economical in the long run, because the price of coal is expected to rise faster than the price of wood. The study estimated that wood prices will escalate at 3.5 percent per year, while coal will go up 5 percent per year. At these rates, the price of coal would rise above wood in about five years.

It also was suggested that the price of coal could be held down by making the facility capable of burning either coal or wood. Thus, if the price of coal were to rise substantially above the price of wood, W. R. Grace & Co. could switch to wood without modification to its facilities. Available technology allows the use of oil, coal, wood, or gas without major modification or adjustments.

The study suggests that a backup capacity should be built into any system for burning wood at the Grace plant. The optimum system, as suggested by Rayson Brothers, would be fueled almost entirely by sawmill waste, including sawdust, log ends, cedar chunks, slabs, and an occasional cull log. All the material other than sawdust would be converted into hog fuel.

Research by Rayson Brothers indicates that 313,000 tons of mill waste per year are produced within 100 miles of Libby when mills are operating at their normal level. Queries to mill operators determined that seven of them, producing a total 168,000 tons of waste annually, were interested in selling it to Rayson Brothers for hog fuel.

Backup would be required to supplant mill waste in case low demand for wood products were to cause some mills to shut down or operate substantially below normal capacity. The likelihood of such production cutbacks is difficult to predict. Lumber production and the consequent mill waste output has been below its normal level in four of the last five years, but only in five of the last 25. Given the relatively small amount of wood waste needed for the vermiculite operation, it is likely that an adequate supply could be found even during severe depressions in the wood products industry. The record shows that an adequate supply would have been available even in 1982, the worst year for wood products since the great depression. The supply of waste could best be ensured through contracts with as many mills as possible, increasing the odds that some of them would always be operating or that wastes from several mills could be combined to supply the need.

If sufficient mill wastes were not available, then logging residues or noncommercial timber stands could be used. Research indicates there is well over a 100-year supply of such material available in the Libby area.

Additional backup could be provided by coal, which is expected to be available in large amounts for a long period of time from the Canadian mines.

As a result of the study, Rayson Brothers proposed to enter a 15-year contract to provide fuel for use in drying vermiculite at the W. R. Grace mine.

Under this proposal, Rayson Brothers would operate a wood yard in Libby where wood wastes would be delivered for chipping. In most cases the waste would be hauled to the site by employees of Rayson Brothers, although independent operators might also arrange to deliver the material. Rayson Brothers would process the waste in their own hog fuel chipper and haul it to storage facilities at W. R. Grace as needed. Twelve loads a day would be required at full operation.

The hog fuel would be burned in a fluidized bed gasifier, which would provide low Btu gas for combustion in the vermiculite dryer.

No significant environmental impacts are foreseen in the system proposed by Rayson Brothers. High combustion temperatures would result in very low concentrations of particulates in combustion gases, and mechanical collectors would be used to capture whatever there were before they could escape to the open air. If coal were used, some sulfur collection equipment might be required to prevent sulfur dioxide emissions, although the sulfur content of the coal is only 0.3 percent and any potential emission of sulfur dioxide is expected to be within acceptable levels without pollution controls. Approximately 240 tons of wood ashes would be produced each year, and this would be disposed of along with waste materials from the mine. Fifteen new jobs would be created.

Financing methods are a crucial aspect of the Rayson Brothers proposal. Rayson Brothers suggests that substantial tax advantages could enhance the feasibility of the project if the gasifier were owned by them. This would have the effect of providing lower-cost financing. Industrial Revenue bonds could be used to meet additional financing requirements.

The project, as proposed, was favorably received by W. R. Grace, which intends to switch from fuel oil to a lower cost fuel. However, any moves in this direction have been temporarily stalled by low demand for vermiculite, down 50 percent from normal production.

Copies of the report, titled Libby Bioenergy Project: A Study to Replace Oil and Coal With Wood, are available through interlibrary loan from the Montana State Library, 1515 East Sixth Avenue, Helena, Montana 59620. Contact Howard Haines, Energy Division, 1520 East Sixth Avenue, Helena, Montana 59620-2301, (406) 444-6697, for more information.

MONTANA BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

MONTANA STUDIES USE OF CHICKEN MANURE TO PRODUCE METHANE FOR HEAT, ELECTRICITY

The use of livestock manure to make low-Btu gas seems to be one of those good ideas whose time is not quite yet. At least that is the general conclusion of a preliminary study financed by the Montana Department of Natural Resources and Conservation (DNRC) to determine the feasibility of using chicken manure from a commercial egg farm to satisfy the farm's energy needs.

The study examined the possibility of producing "biogas," which consists of 60 percent methane and 40 percent carbon dioxide, at the Montana Farms egg farm near Townsend. This operation maintains an average population of 110,000 laying hens that produce over 5,000 tons of manure annually.

Consulting engineers from the firm of Brown and Caldwell performed the study. As part of the investigation, they analyzed three different technological approaches to making biogas at Montana Farms.

The first of the technologies tested was "conventional technology." As envisioned for this project, conventional technology would use manure diluted with water to 7 percent solids and digested in a heated tank where the mixture would be stirred for 30 minutes every 6 hours. Variations of this method are well-known and have been applied to many different situations.

The second technology tested was termed "innovative technology," which used undiluted chicken manure with a solids content of about 25 percent. This manure would be mixed with some of the contents of the digesters before itself moving to the digesters. There would be two heated digesters for this system, with the same stirring schedule used for conventional technology.

The third technology tested was "low technology," which used the same dilution down to 7 percent solids as conventional technology, but with digestion taking place in a buried concrete tank without stirring. Digestion with all three of the technologies was "anaerobic." The term "anaerobic" indicates that the process depended on "anaerobic" bacteria, which live and function in the absence of oxygen.

Several critical operating conditions were noted in the testing. First, it was determined that the most gas was produced when temperatures were held within two degrees of 95 degrees F. Second, it was necessary to maintain a pH between 6.6 and 7.6. The elevated ammonia level normally found in chicken manure was a potential problem because the bacteria that produce methane have a low tolerance for ammonia. To cope with this problem, the researchers produced bacteria that were acclimatized to high ammonia levels. Consequently, the experimental digesters operated well at ammonia levels substantially above those noted in the technical literature on biogas generation.

Besides testing three separate technologies for producing biogas, the investigators analyzed different options for various components of the systems. One of the options pertained to the various ways of collecting and handling manure. First, it had to be determined whether the manure should be handled as a solid or as a liquid. In either case, some of the possibilities would require paving of the floor under the chicken cages, which would not be economically feasible at Montana Farms.

The researchers concluded that the most practical system for collecting manure at Montana Farms may be the present system, where a scoop-equipped loader removes the manure whenever the hens are replaced. The hens have a productive life of about 15 months, and there are three houses operating on a staggered replacement schedule, so one-third of the hens are replaced every 5 months. The researchers recommended testing the feasibility of the present manure removal system if the biogas plant is built. One of the considerations is that fresh manure has a higher content of volatile solids than aged manure, giving it the potential to produce more gas. The loss of volatile matter in the aged manure if collection were infrequent would be partially compensated for by the heat generated when the aged manure begins composting. This heat reduces the amount of heat that has to be added for the digestion process. If too much gas production were lost by collecting manure every 5 months, then other options for more frequent collection would have to be tested.

Other system alternatives studied included the different methods for cooling the biogas-fired engine that would power the generator. In operating an engine on biogas, the exhaust gas must be kept above its dewpoint to prevent the collection of corrosive condensates in the exhaust system.

The temperature of the exhaust gas depends largely upon the cooling system. Either conventional water cooling or evaporative cooling can be used successfully with a biogas-fired engine.

Still another option in the use of biogas is to burn it directly for heat rather than to use it for operating an engine to produce electricity. The researchers concluded that, for Montana Farms' particular situation, the best use of the biogas would be for making electricity. Gas from a conventional biogas production facility at Montana Farms could power a 60 kW generator. That's big enough to satisfy Montana Farms' average electricity demand, with 25 percent of the gas left over to replace propane for space heating and warming egg-washing water.

Neither the innovative technology nor the low technology could produce as much gas as the conventional system with the amount of manure available at Montana Farms. The study indicated that either of these two technologies could produce about 41 kW of electricity, barely more than Montana Farms' minimum requirement of about 40 kW. Neither of these technologies would produce any biogas beyond that needed to power the generator.

The engine also could run on propane, which would be useful during engine start-up, and if biogas were not available. Heat from the engine's exhaust and cooling system would be used to heat the digester tank and water for washing eggs. Any electricity beyond the needs of Montana Farms could be moved through the nearby Vigilante Electric distribution lines into the Montana Power system. Montana Farms would have to negotiate financial agreements with Vigilante and Montana Power for transport and sale of the extra power. The generating system would also have to meet the requirements of the Public Utility Regulatory Policy Act (PURPA).

All three of the technologies would use some form of lagoon system to collect and process the sludge that remains after digestion. With the conventional technology option, the sludge would flow by gravity into one of the eight 80 x 80-foot, 4-foot-deep drying lagoons. In about a week, most of the solids would settle out, and the water remaining would be tapped into another lagoon, 160 feet square and 4 feet deep, where it would be allowed to evaporate. The solids remaining in the smaller lagoon would be left to dry, and the larger lagoon would have enough capacity to allow evaporation of all the wastewater produced. The eight drying lagoons would be filled and drained in turn.

The dried sludge would be removed periodically and disposed of either by selling it to nearby farms or by composting and packaging for sale as potting soil or soil conditioner. Given the additional costs involved in composting and packaging, the study recommends that Montana Farms sell the sludge to farmers as it now sells the raw chicken manure.

The lagoons and all other project facilities would be designed and built to operate under Montana weather conditions, including severe winters. All project equipment except the digesters would be housed in a 20 x 20-foot insulated building, protecting the equipment and making it easier to reclaim heat generated by the engine.

Operation of the digestion and electrical generation systems would be relatively easy, though some daily attention would be needed. The mixing tank probably would be charged with manure daily, and the sludge would be continuously pumped to the digester. The system would allow for the use of heated mixing water in the winter to prevent sludge freezing. A heat exchanger would automatically maintain a set temperature of sludge entering the digester. This set point would be correlated with the digester temperature and modified on a seasonal basis to maintain a digestion temperature of 95 degrees F. The digester would require periodic cleaning. Normally this would be done every three to five years. Debris from the cleaning could be pumped with wash water to the drying lagoons.

The engine-generator system would operate automatically and would include all the safety shutdown and alarm circuitry required for safe operation.

Routine maintenance would be necessary for all mechanical equipment. Lubrication would be required at intervals recommended by the specific equipment manufacturer. The engine would need the most maintenance attention. Maintenance service contracts are usually available through the equipment distributor for major overhauls, but regular tune-up and maintenance are often carried out by the owner. For the system described here, the engine would require minor service every 720 hours (change oil, oil filters, and air filters), a top end overhaul every 10,000 hours, and a major overhaul every 20,000 hours. Minor overhauls should take no more than 2 to 4 hours, so the digestion process would not be disrupted. The 10,000-hour overhaul can likewise be done quickly by using exchange parts. For the 20,000-hour overhaul, the engine would be off-line for several days. This shutdown would be a good opportunity for periodic digester cleaning.

The engineering study concluded that the production and use of biogas from chicken manure at Montana Farms was feasible technically but not economically. Capital cost to install the system was estimated at $407,000, with annual operating and maintenance costs of approximately $40,000.

Finance costs would increase the 10-year cumulative net cost to $497,000. By contrast, the estimated cumulative net cost of operating Montana Farms as it currently is over the next 10 years is $138,500. It would require 80 percent funding with a grant and a 5 percent annual increase in energy costs to make the biogas system pay for itself in 10 years. The project would be economically viable if all energy produced could be used on-site or sold profitably. However, current electric buyback rates and the wheeling charge would not meet the costs of electric generation at this time. The cost for on-site generation from biogas is lower than buying from the grid.

Ralph Morand, one of the owners of Montana Farms, is somewhat discouraged by these figures, but still hopes that a biogas system may someday be installed. "It's something we need," he said, noting that energy costs are one of the main expenses of egg farming, and that they aren't going to go any way but up.

Copies of the report, entitled "Montana Farms: Biomass/Cogeneration Feasibility Study," are available through interlibrary loan from your local library or from the Montana State Library, 1515 East Sixth Avenue, Helena, Montana 59620-2301, (406) 444-6697, for more information.

MONTANA BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

FUTURE OF HOUSEHOLD WOOD BURNERS TOUGH TO CALL

Although there is no certainty in the prediction, the use of firewood in western Montana may increase 60 percent by 1995. This was the conclusion of a study funded by the Montana Department of Natural Resources and Conservation, and carried out by technical consultants who used computers to estimate the various influences that could increase or decrease the use of wood.

The study, conducted by Eco Northwest Ltd. of Helena, notes that the use of wood for home heating declined gradually in Montana from 1880 until 1974. Then, rapidly rising energy costs stimulated a boom in the use of firewood. Between 1974 and 1980, estimated annual firewood consumption in Montana rose from about 100,000 cords to about 315,000 cords.

This rise was due partly to the "energy crisis" and partly to the number of new households outside city limits without access to natural gas, according to the study. The number of households in Montana grew 30 percent between 1970 and 1980, from 217,304 to 283,742. Sixty percent of this growth was outside the city limits, where natural gas was usually not available. Consequently, most of the new houses had either electric heat with wood backup, or wood heat with electrical backup.

Besides purely economic forces, the use of wood was influenced by other, less predictable factors. One of these is the "wood burner ethic," which cannot be precisely defined, but relates to a consumer revolt against rising utility prices. Supporters of the wood burner ethic believe that they are saving money and gaining independence by taking a more active role in satisfying their energy needs. Many wood burners also prefer the radiant heat from wood stoves to other types of heat from other kinds of heaters.

The effects of air pollution from burning wood and the relative severity of present and future regulations controlling such pollution also will influence how much wood is burned in the future. Missoula and Helena both have regulations governing wood burning, and other communities are expected to follow this trend. Existing regulations also may be tightened. On the other hand, pollution controls such as catalytic converters and more efficient stoves may make it possible to burn wood without causing severe pollution problems.

Another influence on heating with wood is the firewood supply. As firewood gets scarcer close to towns and people have to go farther to get wood, costs will go up, and competing heat sources such as natural gas and electricity may become relatively cheaper.

In analyzing these various influences, the researchers interviewed people from different categories connected with wood burning in Montana, and then used computer simulations and economic forecasting methods to predict the probable future of wood heat in the state. The people interviewed included wood stove dealers, timber staff officers with each of the national forests in western Montana, and commercial woodcutters.

Stove dealers in Butte, Bozeman, and Kalispell said wood use will remain stable over the next five years because stove sales are decreasing, the novelty of burning wood is past, wood is getting scarcer, and new stoves are more efficient. A Missoula dealer said wood pellets may displace regular firewood in that community. The dealers said that 60 percent to 70 percent of firewood is cut by the users, with the remainder purchased.

The timber staff officers suggested several measures that would make it easier for people to get firewood out of the national forests. These include piling slash nearer roads, construction of more roads, and lower prices for firewood permits. The officers were about evenly divided as to whether wood use will increase or level off. They noted that the cost of gathering or buying wood is rising, and suggested that people will become more tolerant of the high cost of conventional energy sources.

The commercial woodcutters interviewed said wood prices will rise because of increasing scarcity. However, 7 of the 10 cutters interviewed said more firewood will be used in the next five years because of rising gas and electricity costs. They also cited recent experience which has seen wood use increase steadily over the last few years. Three of the woodcutters said air pollution regulations and the increasing cost of new stoves may reduce wood use. The cutters said the current cost of a delivered cord of wood ranges from $50 to $75, with $60 or $65 being the most common.

The next phase of the study was a survey of the public. Names were randomly selected from telephone books from all over Montana with emphasis on the Montana Power Company (MPC) service area. A total of 603 people were interviewed, of whom 281 had a wood stove or fireplace. Forty percent of these wood-burning devices had been installed in the previous five years and many more had come with the house when it was purchased. Over 80 percent of those interviewed thought their stoves would pay for themselves in less than five years.

The researchers suggested that the "quick payback" idea probably was wrong. It is based in part on the tendency of woodburners to ignore many of the costs of collecting and burning wood. If the full cost of equipment (pickup operation at 30 cents a mile, $200 chainsaw depreciated over 10 years) is included in the cost of wood, the price rises to about $26 a cord, assuming each cord requires $6.00 worth of gasoline. If people gathering their own firewood place any value on their time, the prices rise further. The study cites an estimate that it takes 8 hours to cut and split a cord of wood, and another 11 hours to tend the fire during the burning of a cord. If each hour consumed in cutting, hauling, and splitting the wood were valued at $4.50, then the cost of a cord would be about the same as if it were purchased from a commercial cutter. The actual out-of-pocket costs would remain at $6.00 for gasoline. Many people therefore would perceive that their total cost per cord was $6. Such perceptions, and the likelihood that they will change as people get tired of gathering wood and it gets harder to find, make it very difficult to predict the future of woodburning.

However, based on available information about attitudes and conditions, computer simulations reported in the study indicate that wood use in the MPC service area will increase from 260,000 cords per year in 1984 to 410,000 cords in 1995, a 58 percent increase. Current estimates indicate that wood provides about 16 percent of the home heating in the MPC service area. By 1995, the study predicts that nearly 30 percent of home heating in the MPC area will be met by wood, if pollution control measures do not hinder expansion of wood use. About half of the predicted increase in wood use is expected to result from the formation of new households. Approximately half the new homes on the MPC grid have electric space heat, and many of these also have wood burners.

Copies of the survey, titled "Residential Wood Fuel Use Assessment," are available through interlibrary loan from the Montana State Library, 1515 East Sixth Avenue, Helena, Montana 59620. Contact Howard Haines, Energy Division, 1520 East Sixth Avenue, Helena, Montana 59620-2301, (406) 444-6697, for more information.

MONTANA BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

STEEP SLOPE TIMBER THINNING STUDIED

The need to thin dense stands of small-diameter timber on steep slopes presents some serious questions. Can thinning be economically performed in such stands, and, if so, what type of equipment is needed, at what cost, and with what manpower requirements?

Until recently, the timberland owner confronted with these questions was pretty much on his own, but many answers are now available as a result of a demonstration project performed by the managers of the Lubrecht Experimental Forest east of Missoula, Montana. The results should interest not only those interested in thinning, but also commercial firewood cutters and other small-scale woods operators.

The project, funded by the Montana Department of Natural Resources and Conservation, tested different types of harvesting equipment under various conditions on slopes steeper than 25 percent. Slopes this steep cannot be negotiated safely by rubber-tired or tracked skidders. Accordingly, the systems tested all used cable winches to move the trees from where they were cut to where they could be reached with a grapple-equipped tractor or skidder.

This gathering of trees is called "yarding," and the equipment used for this project included two "cable yarders" specifically designed for such work. For small-scale harvesting over shorter distances, the project testing included a farm tractor equipped with a winch on a 3-point hitch.

Cutting and yarding were carried out under various conditions on eight different plots, some of which were on the Lubrecht Forest and others on the property of cooperational landowners nearby. The trees harvested were made into a variety of products, including hog fuel chips, conventional firewood, posts, poles, rails, and pulpwood.

A second goal of the project was to harvest timber without causing unnecessary environmental impacts, such as soil disturbance and damage to trees left standing after thinning.

The two yarders tested are specialized machines with cable winches designed to retrieve small diameter trees as much as 650 feet up or down slope. The yarders can be mounted on a trailer or flatbed truck, and so are easily moved from position to position. The winch on the farm tractor was capable of moving trees up to 200 feet. All the machinery was chosen on the basis of relatively low cost, availability, or the capacity to be used with farm machinery that a farmer or rancher normally would have available.

The biggest and most expensive yarding machine used was the Clearwater Yarder, which was developed by the Missoula Equipment Development Center of the U.S. Forest Service, specifically for use by small operators doing thinning or other small-tree, steep-slope timber harvesting. A commercially built version of this machine costs about $50,000 to $60,000. It weighs 13,500 pounds and can winch up to 3,500 pounds at a maximum speed of 1,000 feet per minute.

The other cable yarder tested was the Bitterroot Miniyarder, also developed in Missoula by the Forest Service. It is a smaller and much simpler machine that can be built in small machine shops. Parts and materials for assembling one of these cost about $7,500 and commercially built models range upward in cost from $14,500. Engineering drawings are available from the Forest Service for those interested in assembling their own. The Miniyarder weighs only 1,600 pounds, and can easily be mounted in a 3/4 ton pickup or trailer. Cable speed varies with load with a maximum of about 400 feet per minute. It can pull 2,000 pounds at 160 feet per minute.

Both the yarders use a "live skyline" system. In this configuration, two cables are operated with separate winches on the yarder. One of these cables, the "skyline," runs from the skyline winch up to the elevated "fairlead" (a pulley on a tower reaching up from the yarder to provide elevation for the skyline), and then along the yarding corridor to the downed trees that are to be hauled in. At the end of the yarding corridor the skyline is anchored 20 or 30 feet up a stout tree and then tightened with the winch. If the distance from the yarder to this anchor is long and if the terrain drops off sharply, it may be necessary to suspend the mid portion of the skyline from a tree or a cable between trees to keep the skyline high enough off the ground.

The second cable, called the "mainline," extends from the mainline winch through a separate pulley on the fairlead and is carried along the skyline by a mobile "carriage," which runs up and down the skyline on a pulley wheel. When the yarder is uphill from the downed trees, gravity pulls the carriage with the loose end of the mainline down the skyline until it is within reach of the trees. If the yarder is downhill from the trees, the carriage and mainline must be manually pulled uphill to the harvest area.

When the mainline reaches the downed trees, one of the workers attaches it to a load of trees and signals the yarder operator to pull it up. The operator then engages the mainline winch which pulls the carriage up the skyline, trailing the load of trees held by the mainline along the ground below. The elevation of the skyline keeps the butts of the trees off the ground and reduces skid resistance and soil disturbance. When the logs reach the yarder, the operator stops the carriage, slacks the skyline enough to release the tension of the mainline on the load of trees, and detaches the mainline from the load. When enough of these loads accumulate, a skidder or grapple removes them to a nearby processing area or landing.

The tractor winch, which didn't use a skyline, was the simplest machine used for yarding. With this system, a cable from a winch attached to the rear of a farm tractor was manually pulled along the yarding corridor to the downed trees. These winches are available in sizes suitable for use with tractors ranging from 20 to 100 horsepower, and cost from $1,200 to $5,000. Cable speed with these winches can be as high as 430 feet per minute, depending on the load, slope steepness, horsepower of the tractor, and power takeoff speed. The model purchased for use on the John Deere 220 tractor for this demonstration cost $2,700. The tractor and winch system was at its best when downed trees had to be moved 150 feet or less.

One device used both with the yarder and the tractor winch was the breakaway block, which made it possible to pull "around a corner" to avoid obstacles such as trees that were to be left after thinning. This device is particularly useful when skidding trees from lateral corridors off the main yarding corridor where the yarding winch cannot make a straight-line pull.

Essentially, the breakaway block is a pulley attached to a tree that is aligned with the lateral yarding corridor. The cable from the yarder runs through the block, where it turns an angle and then runs off to the side to the downed trees. After the cable is attached to the trees and the yarder begins winching it back, the load moves toward the breakaway block until a cable clamp on the line trips the breakaway arm which frees the line from the pulley. The direction of pull then changes and the load moves directly toward the yarder. The line must be manually replaced in the breakaway block for each pull.

Other equipment included a farm tractor equipped with a rear-mounted grapple which was used on some plots to move logs from the yarder to the landing or processing area. On some plots, John Deere 440 and 540 rubber-tired skidders were used for this function. When trees were made into hog fuel, a portable chipper was used at the landing.

The harvest process on each plot usually consisted of four stages - felling and bunching, yarding, swing (the process of moving the harvested trees from the yarder to the landing or processing area), and processing.

In the felling and bunching step, a crew of two or three people fell the trees with the butts toward the yarding corridor. In general a two-person falling crew consisting of a sawyer and a pusher/stacker was the most efficient. In timber under 4 inches diameter at breast height (dbh), the crew would bunch the trees into piles so that several could be removed with one hookup. In most cases, the felling stage was completed before yarding began. However, on portions of some plots felling was conducted at the same time as yarding. Although this approach was inefficient in thinning operations where a dense stand was left, it was efficient where a more open stand was left. On one plot where yarding and felling were done at the same time, the crews tended to interfere with one another.

During the yarding phase, the crew consisted of two to four people, depending on the characteristics of the site and the type of machine used. Three winched while the other two pulled cable and hooked up the logs. The four-person crew was used part of the time with the Clearwater Yarder. The Miniyarder crews varied from two to three people. With the Clearwater Yarder loader, and the Miniyarder, one person operated the machine and unhooked incoming loads. The remaining crew members were in the woods and were responsible for hooking up the logs and putting the cable into the breakaway blocks. The yarder operator and woods crew communicated with small FM radios.

The swing phase normally was performed by one person moving the harvested trees from the yarder to a landing area for processing or decking. Equipment used for this was either a grapple-equipped farm tractor or a John Deere 540 or 440 rubber-tired skidder. The larger skidder was necessary to match the increased yarding capacity of the Clearwater on some plots. On one plot where the trees were chipped into hogfuel, the tractor operator either piled the trees into stacks or fed them directly into the chipper.

The crew and machinery involved in the processing step varied with the products generated. Two people operated the chipper and grappled tractor on most of the plots that produced hog fuel. On plots where pulpwood was produced, one or two people limbed and bucked the trees on the landing. In some instances, depending on landing location, one of the landing crew or a third person used another tractor either to stack trees for chipping or to set them aside for use as rails, poles, and pulpwood. The swing person also assisted in decking material. The choice of end products was dictated by tree species and size, available landing space, condition of the road leading to the area, and desires of the landowner.

Only three of the plots were harvested with the Clearwater Yarder. The larger capacity of this machine made it possible to harvest more trees in a shorter period of time, and eliminated the need to cut larger trees into pieces before they could be yarded. A third factor was crew size. In general, the smaller the crew, the more profitable the operation.

Two of the profitable plots were cleared rather than thinned, and the third was thinned with wide spaces left among remaining trees. The thinning operations were more costly primarily because they required more time-consuming maneuvering to avoid trees left standing.

Cost greatly exceeded revenue on plots that had small trees, or where the trees left standing were densely spaced. Costs were also driven up when logs at a given location were processed into more than one product primarily because of the extra handling and set-up time required. One of the profitable plots netted only $3.96 an acre, although another brought in a net profit of $414.71 per acre, and the third produced a per acre profit of $611.87. Losses per acre on other plots ranged from $329.65 to $607.52.

The directors of the project cautioned against making too much of the profit and loss figures, for several reasons. First, the point of thinning timber is less to make an immediate profit than to improve the growth of the remaining trees and to reduce the potential for damage from fire or insects. Thinning is a notoriously expensive operation. First, the costs and benefits of thinning or small timber harvesting can vary greatly according to the particular situation. For example, a ranching operation that provides its own labor probably would incur labor costs considerably lower than the cost of union-scale logging labor, particularly if most work is done by the ranch owner's family. The profitability figures cited in the study were calculated with the assumption that labor would be compensated at $7.50 an hour. Other major costs were the depreciation costs of equipment, of which the highest was $28 an hour for the hog fuel chipper. At the other end of the scale, depreciation for chain saws was calculated to be $1.50 per hour, and the John Deere Model 2240 tractor used for winching was depreciated at $5 an hour. Clearly, these figures would vary from case to case.

Other variables affecting profitability include slope steepness, tree density, amount of underbrush, and other environmental and operating conditions that could hinder the work.

Given the variables that could affect costs and financial yields, it may be more useful to consider productivity levels and let the potential user determine which harvesting system best meets his needs. The researchers calculated productivity for each of the following: trees harvested per hour of operation of each system; trees harvested per crew member hour; cubic feet of wood per system per hour; and cubic feet of wood per crew member per hour. Crew members harvested the most cubic feet of wood per hour when the Clearwater Yarder was used in clear-cutting relatively large lodgepole pine for use as pulpwood. Production was reduced by cutting smaller trees, using the less powerful machines, thinning in dense stands, making more than one type of product from trees at a given location, and using unnecessarily large crews.

The project results are displayed in a self-guided tour at Lubrecht Forest. Persons wanting more information or a demonstration of procedures may contact Hank Goetz, manager at Lubrecht Forest, Greenough, Montana 59836, phone (406) 244-5524.

Copies of the report, titled "Thinning on Steep Terrain with Low-Cost Cable Yarders," are available through interlibrary loan from the Montana State Library, 1515 East Sixth Avenue, Helena, Montana 59620. Contact Howard Haines, Energy Division, 1520 East Sixth Avenue, Helena, Montana 59620-2301, (406) 444-6697, for more information.

MONTANA
BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

SOLAR POWER PREVENTS STOCK WATER FREEZING

Low-cost solar collectors can prevent freezing in stock-watering tanks even in severely cold weather, according to a study performed on the frigid high plains of eastern Montana.

Water tanks insulated and equipped with the solar collectors did not freeze even when wind chill factors dipped as low as 60 degrees below zero. The research, funded by the Montana Department of Natural Resources and Conservation and carried out by George Austin of Glasgow Solar Thermal and Construction, was aimed at finding a way to prevent freezing in remote stock tanks so that stockmen wouldn't have to check them every day during cold weather. Some tanks in eastern Montana are 50 miles or more from the home ranch, so a daily visit requires a substantial amount of time and energy.

Two different types of solar collectors were tried: "active" units, so called because they have moving parts, and "passive" units which have no moving parts and are much simpler and cheaper.

Four tanks were equipped with passive collectors. The "collector" in these devices is a fiberglass tray partially submerged in the water and painted black to increase the solar heating effect. The collector is attached to the insulated cover of the tank and covered with an insulated housing that has a double-glazed opening on the south side to admit sunlight. This sunlight heats the collector which transmits the heat to the water in the tank. A 4 x 6 foot collector was used for tanks up to 600 gallons, and a 4 x 8 foot for tanks from 600 to 1,500 gallons.

With the "active" solar collectors, equipment used included a 4 x 8 foot vertical collector, a 12-volt solar-driven motor that powered a fan, and a length of flexible tubing submerged in the water. Solar energy operates the motor which causes the fan to blow air through the baffles in the collector plate and through 15 feet of submerged tubing where it warms the water before returning to the collector. Two tanks had the "active" installation. Study results indicated that the active units worked as well as the passive ones to prevent freezing, but were less reliable because of the moving parts. One motor failed because it was in the stream of hot air from the collector plate, and another was shot out by hunters.

The active units, costing about $750 each also were substantially more expensive than the passive. The passive collectors were estimated to cost about $350 each if custom built of new materials, but much less if some materials were already on hand, or if second-hand materials were used. Costs could be cut further if the rancher assembled the unit himself. The average cost of new materials for framing, sheathing and insulating runs about $100 per tank. The fiberglass collector for the passive units can be purchased for about $130.

For water tanks located near ranch buildings, where they can be checked easily, freezing problems can be reduced by simply covering and insulating the tanks. Such treatment would prevent freezing on all but the coldest days by preventing escape of the warmth from the water entering the tank from the ground.

Austin estimated that the cost of the insulation and solar units could be paid back in three years or less through savings in gasoline, vehicle wear and tear, and man-hours from not having to check the tanks every day in cold weather. He said about 300 gallons were saved by the insulation and solar facilities during the winter of 1985-86. Two of the tanks were previously heated by electric heaters, which probably would have required $200 each in electricity during the monitoring period, according to Austin.

Copies of the report, titled "Solar Stock Tanks Near Glasgow, MT," by George Austin, are available through interlibrary loan from the Montana State Library, 1515 East Sixth Avenue, Helena, Montana 59620. Contact Howard Haines, Energy Division, 1520 East Sixth Avenue, Helena, Montana 59620-2301, (406) 444-6697, for more information.

MONTANA BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

CORN COBS TO BE BURNED IN PLACE OF FOSSIL FUELS

Add corn cobs to the list of things that can be burned in place of fossil fuels. Researchers at the Southern Agricultural Experiment Station at Huntley, Montana, have found that half the corn cobs from a field have enough heat value to dry all the corn from the same field.

Further, the equipment necessary to burn cobs and other field waste is readily available "off the shelf," and has been used for some time in the Midwest. Operating costs for the cob burner can be as low as 4.3 cents per bushel of dried corn, compared to about 11 cents when propane is used.

The burner used in research at the experiment station could burn not only cobs, but also the stalks and leaves of the corn plant, or straw from other crops, or, for that matter, wood chips. The cobs gave the fewest problems.

The main problem encountered was the failure of the feed system with some types of fuel. Straw was particularly troublesome, with a tendency to clog. Cobs mixed with other corn waste fed more reliably, and cobs alone fed the best. Because of these feeding problems, it was necessary to watch the burner while it was functioning. If this were not necessary, the cost of labor could be cut substantially. Gilbert Stallknecht, superintendent of the research center, said the feed system could be readily modified to eliminate problems, at least when cobs alone were used as fuel.

Stallknecht said the most efficient way of collecting cobs and other corn waste probably would be by using a combine equipped with a chaff saver. This device would dump the waste in bunches where a tractor could be used to load it on a truck, which would then deliver it to a hopper that would feed into the burner. Or, he said, it might be preferable to store the cobs in a dry place for use the next year. Cobs delivered from the field normally have about 30 to 45 percent moisture, he said, adding that they do not burn effectively at moisture levels above 33 percent.

The waste in the hopper is moved by an auger into the burner. This auger is thermostatically controlled, so it adds fuel when burner temperature declines to a given level.

The burner normally operates at 1,200 to 1,500 degrees F. Hot gases from the burner are passed through a heat exchanger that heats air to a temperature of between 120 and 160 degrees F. This air then is passed through the perforated drying floor into the corn that is to be dried. This corn is piled about 5 feet deep, with 1,200 to 1,500 bushels in a batch. One day's operation of the burner was enough to dry the corn from a moisture content as high as 25 percent to a level below 15 1/2 percent. Once dried to this level, corn can be stored for years, compared to the few months it will keep if not dried. This gives the grower the flexibility to wait for better prices.

Corn is not a major crop in Montana at present. Only 11,000 acres were harvested in 1985, down from 15,000 in 1984. Still, there is reason to think more corn may be grown in the state. Stallknecht points out that hybrid strains of corn developed for cold climates could dramatically increase production per acre in Montana. Right now, he said, corn farmers in a good year get about 160 bushels per acre. Test plots at the experiment station with the new hybrid seed have produced more than 250 bushels per acre, he said. If corn were to become a more important crop in Montana, there might be considerable interest in using corn waste as fuel in drying the corn.

The burner also could be used for other purposes. Stallknecht said the next phase of experimentation with the burner will test the feasibility of heating water for use in heating a structure, such as a shop, or possibly a greenhouse. The burner is equipped with rubber-tired wheels and can readily be placed wherever it is needed.

Cost of the burner with all its accessories is about $12,000, Stallknecht said, compared to about $6,500 for a propane burner with the same output. Thus, if assuming 4.3 cents-a-bushel fuel cost to dry corn by burning cobs and 11 cents-a-bushel to use propane, and with 150 bushels of corn per acre, it would take about 1,000 acres of corn to pay back the difference in purchase price of the burner. Labor costs associated with gathering the waste could reduce this advantage.

Copies of the report, titled "Utilization of Biomass to Dry Whole Corn," by Gilbert F. Stallknecht, are available through interlibrary loan from the Montana State Library, 1515 East Sixth Avenue, Helena, Montana 59620. Contact Howard Haines, Energy Division, 1520 East Sixth Avenue, Helena, Montana 59620-2301, (406) 444-6697, for more information.

MONTANA BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

ENERGY POTENTIAL OF LEAFY SPURGE, CATTAILS, AND FUEL BEETS

What could cattails, leafy spurge, and a type of sugar beet possibly have in common? Researchers at Eastern Montana College (EMC) have completed a series of studies on all three that link these plants as sources of fuel alcohol. The sponsor of the project is the Department of Natural Resources and Conservation (DNRC), with additional support from EMC and the U.S. Department of Energy.

This project is unique in biomass studies because it identifies plants already well-adapted to Montana's soils and climate that could be grown as feedstock for fuel production, rather than for their food or fiber content. Leafy spurge and cattail are plentiful in their natural state, and fuel beets can be cultivated in areas suitable for sugar beets. All three plant species in the study are disease-resistant and promise to be highly productive.

Leafy Spurge

If a weed is "a plant nobody has found a use for," leafy spurge qualifies--except that researchers have now found several uses for this noxious weed, which infests over 500,000 acres in Montana in 54 counties.

This tough, fast-spreading plant has moved rapidly across North America since the early twentieth century. Several different strains now thrive to aggravate farmers throughout the northern plains. Its very toughness, however, has made it easily adaptable to harsh climatic conditions and marginal lands, and this quality could make spurge a useful plant.

As most farmers have found out, spurge has almost no natural enemies--insects and plant diseases don't find it irresistible. Neither is it easily eradicated; its root system is complex--both lateral and horizontal roots anchor it in the ground--and vertical roots usually penetrate the soil to depths of well over 7 feet. The plant grows about 30 to 40 inches high, with a woody stem and flowers that cluster on umbrella-like spokes around a central stalk. In late summer and fall, the seeds are propelled from their pods, and scatter to produce a new crop. The roots survive from one year to the next, ensuring a continuous stand.

Back in the 1930s, researchers were looking at spurge with an unfriendly gleam in their eyes. They were trying to find its weaknesses so they could eradicate it. Recent studies, however, indicate that spurge has promise as an energy crop. Investigation has shown that several vegetable oils can be used as fuel--some can be used as a substitute for diesel oil. Under a grant funded by the Department of Natural Resources and Conservation, Professor Stanley M. Wiatr of Eastern Montana College has completed a study of the possibilities of using leafy spurge as an alternative fuel crop.

Dr. Wiatr evaluated the productivity of natural stands of leafy spurge in south central Montana and determined the proportion of useful vegetable material--biomass--found in the plant. His analysis required separation of soluble materials such as oils and sugars from insoluble materials such as starches, lignin, crude fiber, and ash. A colorimeter, a device for measuring caloric energy, was used to perform analyses on the biomass of the whole plant and of the soluble and insoluble fractions to find the energy content of these materials and the amount of energy in the plant. This information allowed the researchers to compare the productivity of spurge with other vegetable species and then to compare them with other possible biofuels such as vegetable oils and ethanol.

In a previous survey of 40 species of prospective oil-bearing plants, spurge ranked as a mid-range oil producer. It also ranked midway as a producer of carbohydrates and total digestible nutrients for feed. Two other species of spurge have been reported to contain sufficient hydrocarbons and oils to be competitive in yield when compared to conventional oil crops such as safflower seeds.

Leafy spurge is more promising as a multi-purpose crop, because it can produce fiber as well as fermentable carbohydrates that could be converted to ethanol for fuel alcohol production. Leafy spurge isn't part of the human food chain, so it wouldn't interfere with the economics or politics of food production. In fact, any protein remaining after removal of energy feedstocks (starch) could be used to increase input into the food chain. One researcher suggests that the protein-rich meal left after oil was removed from crops like safflower, sunflower, and rapeseed would pay for the cost of extracting and processing the oil.

Cultivating leafy spurge as a field crop would not require energy-intensive or costly methods. If anything, spurge has demonstrated that it thrives on no-till areas. To the surprise of one researcher, though, one species of spurge responds favorably to irrigation, which suggests that with a little attention, leafy spurge might become a viable fuel crop in Montana.

Cattails

Instead of eradicating stands of cattails in low-lying areas, farmers could be encouraging their growth, according to a recent study carried out under a grant to Eastern Montana College at Billings. Funded by the Department of Natural Resources and Conservation, the study indicates that the rhizomes (rootlike stems) of the cattail contain starch in sufficient quantities to be a feasible source of fermentable carbohydrates, with ethanol as an end product.

One of the principal purposes of the study was to establish a base for future investigations into the usefulness of cattail as a multi-use plant. Researchers selected two cattail marshes in south central Montana--a 5-acre marsh 7 miles west of Billings and a 20-acre area west of Park City.

The West Billings crop was harvested four times, beginning in late April and ending in October; the Park City crop was harvested four times beginning in mid-May and ending in October. On both sides, the first harvest was of live rhizomes only. For each harvest, six plots were selected; all were at least 6.5 feet in each direction from the others. The above-ground biomass was clipped at water or soil level. The remainder was dug with a post spade to a depth of 8 to 16 inches. At this level most live rhizomes and other biomass were well-stratified. All rhizomes were washed twice, and then separated into living or dead growth. All of the biomass was weighed, air-dried at 68°F to 86°F to constant weight, and then reweighed.

The two sites initially produced markedly different amounts of biomass--that of Park City had a maximum standing crop of 65.9 tons per acre, and the West Billings site had 45.2 tons per acre. However, as the harvests continued, a progressive increase in live biomass was evident in both sites, and the maximum yield was almost the same for both at the end of the season. But, although the yields were quite similar, the percentage of live rhizomes differed--Park City had 69 percent, and West Billings had 50 percent. If these two sites are any indication, crops of rhizomes and above-ground growth may vary considerably in cattail stands.

Analyses of the biomass samples included chemical analyses, calorimetric measurements, statistical comparisons, and investigations of extraction methods.

Chemical analyses indicated that cattails have a low (2.4 percent) oil content. Live rhizomes from the Park City site had high polyphenol content throughout the harvests, and hydrocarbons were low for all of the biomass.

Lignin, crude fiber, and ash were major constituents of the residue remaining after extraction of the oils, polyphenols, and hydrocarbons. About 50 percent of the above-ground biomass was lignin, and the live rhizomes contained 25 percent lignin. (Lignin is a substance that binds the cellulose fibers in some plants and strengthens their cell walls.) Crude fiber content was less than lignin for all biomass, and ash ranged from 5.5 percent to 7.6 percent at the Park City site and 9.6 percent to 14.5 percent at the West Billings site.

Sugar content of the above-ground biomass did not exceed 2.5 percent at either site, and was negligible for dead rhizomes and standing dry matter.

Starch content was in excess of 20 percent in live rhizomes from both sites by season's end. However, dead rhizomes and standing dry matter may represent significant amounts of the total starch reserves in well-established stands of cattails. At the end of the growing season, dead rhizomes had 15 percent to 39 percent of the starch found in living rhizomes.

Protein content of live rhizomes from both sites had a mean of 7.6 percent. Above-ground biomass had a protein content of 5.8 percent.

The combined ethanol yield from the starch and sugars of above-ground biomass and live rhizomes would be 474 gallons per acre. Approximately 70 percent of the ethanol, or 333 gallons per acre, would be derived from starch and in live rhizomes. Sugars in live rhizomes would contribute another 20 percent, 97 gallons per acre. Living rhizomes from an October harvest would contain 90 percent of the fermentable carbohydrates.

This study indicates that rhizome starch was the single most abundant source of fermentable carbohydrate in cattail biomass. This annual yield is substantially less than estimates of fuel alcohol production from beets, but greater than estimates of ethanol yield from cereal grains.

Standing crop, however, is not equivalent to annual productivity because of the variation of biomass composition. Energy yield at harvest should be used as the basis for comparison.

A biomass conversion program would in all likelihood use starch produced annually in cattail rhizomes as the feedstock for ethanol production. Rhizome starch alone would produce the equivalent of 272 gallons of ethanol per acre annually. But sugar or fuel beets can produce sucrose equivalent to 486 to 890 gallons of ethanol per acre annually, so harvesting cattail rhizomes solely as a feedstock for ethanol production would not be justified.

At present, the best use of cattails appears to be as a multi-use crop. The researchers of this study believe that the protein remaining after processing for fermentable carbohydrates should be evaluated as a potential livestock feed. Other uses can be made of the lignin and crude fiber, especially gasification into fuel and production of industrial chemicals. Long term goals indicate genetic improvements could increase starch content in the rhizomes, increase rhizome biomass, and reduce leaf biomass.

These hardy plants can live in polluted water like that in mine tailing ponds, and in fact, not only survive, but improve the water quality just by being there. Some researchers have suggested using cattail ponds to offset the effects of several different types of groundwater pollution. Since marshes and swamps rank high on the list of productive ecosystems, this may well be another sound use of cattail in the future.

Fuel Beets

Southeastern Montana has been an ideal region for high quality sugar beet production for several decades. Recently, another type of beet is being considered--for other purposes. Fuel beets offer new possibilities for ethanol production. The fairly new term "fuel beets" is used to denote any beet that has potential as feedstock to produce fuel alcohol.

Fuel beets are hybrids of sugar beets and fodder beets and hold the most promise for alcohol production. Unlike sugar beets, these hybrids have a larger root mass, and, although individual plants contain less sugar, their high root yields more than compensate for lower sugar content. The potential yield of fuel alcohol per acre would be greater than that for sugar beets.

In a recent study undertaken at Eastern Montana College in Billings, several varieties of beet were investigated as sources of alcohol. Seeds planted were of both European and American stock. Planting, cultivation, and harvesting were carried out in collaboration with Montana State University's Southern Experiment Station at Huntley, Montana. At the end of the growing season, beets were harvested and weighed for both fresh and dry weight. Tests were then carried out to determine fermentable sugar content, protein, and insoluble carbohydrate for leaves and roots.

Sugar analyses were performed at the Great Western Sugar Company in Billings using industrial methods of beet preparation. Other procedures were used to find the percentage of oils, polyphenols, hydrocarbons, and residue. The energy content and biomass of the plants was also determined.

Several of the fuel beet varieties tested produce high yields of fermentable carbohydrates. In fact, some fuel beets produce three to ten times more carbohydrates than barley, wheat, and corn grown in Montana. These high-yield fuel beets could produce 10 percent to 30 percent more alcohol per acre than high quality conventional sugar beets. Some fuel beets can produce over 900 gallons of alcohol per acre. Using 10 percent of the land now used for sugar beet production, growers could sustain a fuel alcohol industry with an annual production capacity in excess of 100 million gallons.

Although at the moment prices for fossil fuels are dropping, only an optimist would think that situation will continue--nor are fossil fuel supplies inexhaustible. So it is very likely that at some time in the near future, the knowledge acquired in these studies will be put to use.

The three reports on this project, entitled "Fuel Beets: A Prospective Energy Crop for Montana," "Energy and Biomass Potential of Cattails in Montana," and "Biomass Potential of Leafy Spurge," are available on loan from the Montana State Library or by writing to DNRC, 1520 East Sixth Avenue, Helena, Montana 59620-2301 or calling (406) 444-6697.

MONTANA BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

RESEARCH FINDS WAY TO MAKE SAFFLOWER OIL INTO DIESEL FUEL

Research at Montana State University indicates that safflower oil can be refined into fuel for truck or tractor diesel engines.

Normally, the use of vegetable oil as fuel causes carbon deposits inside engines. Also, the mixing of unburned vegetable oil with lubricating oil results in "polymerization" (the joining together of small molecules into large ones), with the consequent formation of gums in the oil and eventual engine failure. Examining this situation, researchers at MSU, led by Dr. Warren Scarrah of the Department of Chemical Engineering, concluded that vegetable oil could not be used successfully as diesel fuel unless it was processed to eliminate these problems.

The researchers concentrated their efforts on oil from safflower, which grows well in Montana and could be cultivated in large quantities. Theoretically, Dr. Scarrah said, a farmer should be able to plant 10 percent of his land to safflower and derive enough fuel from it to run his entire operation.

The carbon deposition problem was solved by treating the vegetable oil to break large molecules into smaller ones that burn without carbon deposition. However, this treatment did not eliminate the polymerization.

In looking for possible ways to prevent polymerization, the researchers discovered that the problem could be eliminated if the fatty-acid portion (85 to 90 percent of the safflower oil) was converted to soap and then thermally "cracked" much like crude petroleum to make diesel fuel. The resulting fuel did not cause polymerization in oil intended for high-speed diesel engines, such as those used in tractors or trucks, but polymerization still occurred in lubricating oil intended for use in medium-speed diesels, such as those used in railroad locomotives and electric generation. Researchers believed the lack of additives in the medium-speed oil somehow contributed to the polymerization.

The investigators are now undertaking new studies to eliminate polymerization in the medium-speed oil. They also are looking for better ways to make and refine the soap, and are investigating ways to enhance the conversion of the safflower oil into usable fuel.

Dr. Scarrah said the ability to make fuel out of safflower oil could eventually have a major economic effect on Montana and other states where safflower grows. Scarrah said safflower is ideal for Montana's arid climate and is one of the best plants available for rotation in a continuous crop or flexi-crop program. Safflower is not affected by federal farm-program restrictions and could be planted in the "idled" acres taken out of grain production to comply with federal restrictions.

The probable cost of diesel fuel from safflower was not reported, but Dr. Scarrah noted that fossil fuels eventually will be depleted, and the cost of petroleum derivatives will increase as petroleum gets scarcer. Sooner or later, replacements for petroleum products must be found. The safflower-refining process also yields a high-protein meal suitable for animal feed.

If the conversion of vegetable oil into fuel ever becomes routine, Scarrah said, it most likely will be done in commercial-scale plants rather than in smaller farm-scale facilities. The high temperatures required for making the fuel probably could not be safely or efficiently employed on a small-scale basis with part-time operators.

Copies of the report, entitled "Chemical Processing of Vegetable Oil Fuels to Prevent Polymerization," are available through interlibrary loan from the Montana State Library, 1515 East Sixth Avenue, Helena, Montana 59620. Contact Howard Haines, Energy Division, 1520 East Sixth Avenue, Helena, Montana 59620-2301, (406) 444-6697, for more information.

MONTANA BIONOTES

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

WOOD PELLET USE GROWING RAPIDLY IN MONTANA

The use of pellets made from waste wood to replace fossil fuels for home heating and other purposes appears to be growing rapidly in the Northwest and elsewhere.

Pellets are made from sawdust or other sawmill waste, ground to small particles, dried, and forced through a die. Heat and pressure in the die drive off most of the remaining moisture and bond the wood into solid, dense pellets, usually 1/4 inch in diameter. For use in the home, these pellets can be burned in stoves, boilers, or furnaces designed especially for them, or they can be burned in almost any standard wood-burning stove that has been fitted with pellet-burning adapters. Loren Collins, who operates a pellet manufacturing plant in Livingston, Montana, and who has invented a popular device to adapt ordinary wood-burning stoves to burn pellets, says he thinks the pellet business is about to boom.

Five years ago, Collins said, "there were only three pellet-making plants in the country. Now there are over 20, with at least six more on the way." Montana has three plants, the largest of which is Collins' Livingston operation. Collins said his production for this winter probably will be 5,000 to 6,000 tons, depending on the weather, and he has ordered new equipment to double the capacity of his plant for next winter.

Another pellet plant is located in Darby, Montana, and operated by Bitteroot Timber Products. Winston Wanstrath, one of the owners of that plant, said they probably will make about 1,500 tons of pellets this year, and could sell lots more if they had the capacity to make them.

Pellets from the Darby plant are sold through dealers in Kalispell, Columbia Falls, Butte, Anaconda, and other outlets in western Montana. Collins said he sells his pellets through 40 dealers in 40 towns in Montana and Idaho.

In Missoula, Fred Fortune of Missoula Fireplace and Masonry said his store is the biggest retailer of wood pellets in the country. Fortune and his wife have been selling pellets for five years: 40 tons the first year, 80 the next, then 150, and 500 last year, with 1,000 to 1,500 tons this year. Besides the pellets, the Fortunes sell both pellet-burning stoves and pellet hoppers that can be used to adapt regular wood-burning stoves for use with pellets. Mr. Fortune estimated that between hoppers and pellet-burning stoves, they have sold about 200 devices for using pellets. "We're just completely sold on the pellets," he said.

Missoula is considered to have a particularly active market for low emission wood-burning devices because of its severe air pollution problems, and the local pollution control authorities are enthusiastic about the pellet burners. Jim Carlson, representing the Missoula County Health Department, testified at a hearing that the conversion of existing stoves to burn pellets is "very important to Missoula."

The need to reduce air pollution from wood-burning stoves is one of the driving forces behind the increasing popularity of pellet burners. Pollution control authorities in Oregon have certified several models of pellet-burning devices as capable of meeting the stringent new Oregon pollution regulations. This encourages people in polluted areas to convert to the pellet-burning systems. Further encouragement is provided by tax breaks. In Montana, for example, persons investing in pellet-burning devices certified by the Oregon pollution authorities can take 10 percent of the first $1,000 of their investment off on their state income taxes, and can take off 5 percent of the next $3,000.

Pellet-burning devices achieve low emission rates through high combustion temperatures, resulting primarily from the use of a fan to provide combustion air directly to the burning pellets. This results in combustion temperatures in the neighborhood of 2,000 degrees F, high enough to achieve combustion of the particulates, creosote, and carbon monoxide normally emitted from wood combustion.

The gases emitted by pellet burners, consisting primarily of water vapor and carbon dioxide, are at such a low temperature that a chimney of the customary type is not needed. Adequate venting can be obtained with a 3-inch exhaust vent through a thimble in the wall.

Besides having low emission rates, pellet-burning devices are convenient and economical to operate. Pellets are placed in a hopper that is equipped with an auger to feed the pellets into the firebox. Depending on the capacity of the hopper and the rate of burn, one hopper load of pellets can last up to 40 hours, which eliminates having to get up or come home to a cold house. The clean burning of pellets all but eliminates the possibility of chimney fires, so it is safe to leave pellet burners operating when no one is home.

The price of pellets varies with location, and is lower for bulk pellets than for those in bags. In Missoula, the Fortunes sell bulk pellets for $80 a ton bulk, and $100 a ton bagged. A ton of pellets has about the same heating value as 1 1/2 cords of regular firewood.

One possible drawback of using pellets is that the pellet-burning stoves are quite expensive, running around $1,400 each. On the brighter side, the hoppers available to adapt ordinary wood-burning stoves to use pellets are substantially cheaper. Perhaps the most common of these is the Collins hopper, invented by Loren Collins and manufactured in Belgrade, Montana. The Collins hopper is certified by Oregon authorities, and so qualifies the purchaser for a Montana tax break. Purchase price is in the neighborhood of $400, with another $40 for installation. Collins said about 500 of the hoppers will be sold this year through 55 dealers.

Installation of the Collins hopper consists of cutting a hole in the side of a wood stove and attaching the hopper so that pellets carried from the hopper by the stoker auger drop down a tube into the "burn ring," which is an 8 x 8-inch rectangle of tubular metal installed on the hearth of the stove. Combustion air from a fan which is part of the hopper passes through a tube to the interior passage of the burn ring, and is introduced to the underside of the fire through a series of small holes. Collins recommends that users should stir the burning pellets with a poker twice a day to avoid "clinker," a solid substance that forms when ashes are melted and then solidified. Most of the ash is blown out of the burn ring by the 60 cubic-feet-per-minute flow of combustion air, and settles on the side of the stove away from the burner. Steady use of the burner will require that ashes be removed every week and a half. If the stove operator decides to burn ordinary firewood, he need only remove the pellet burner and replace the one firebrick that must be removed to install the hopper. This takes about 30 seconds, according to Collins.

Collins said some stove manufacturers have told him that alteration of the stoves in installing the hoppers does not necessarily void the warranties on the stoves. The installation and use of the Collins hopper may actually prolong the life of the stoves, Collins said. Although the pellets burn at a temperature well above the temperatures normally reached with regular firewood, the stove temperature when burning pellets is normally 750 or 800 degrees, well below the 1300 to 1400 degrees commonly reached with a hot burn using firewood.

At present, the bulk of pellet use is for homes, though industrial and institutional use is increasing.

Schools in St. Ignatius and Fortine are already using pellets, and pellets are being considered for many other schools, including those at Darby and Wisdom. At St. Ignatius, it cost $10,000 to convert the school's fuel oil burner to use wood pellets, and that much was saved the first year, according to maintenance supervisor Roy Martin. So far this year, Martin said, they have burned about 50 tons of pellets, heating approximately 40,000 square feet of space, and have had to take out only 35 gallons of ashes. Pellets can burn extremely clean if the operator experiments with adjusting the system to achieve optimum conditions, he said. St. Ignatius gets its pellets for $60 a ton from a plant 5 miles away, in Ravalli.

The custodian at the Fortine school said a portion of the school is heated with pellets burned in a coal burner. The pellets cost more than coal, ($83 a ton, compared to $50 per ton for Wyoming coal), but the wood is much cleaner and more pleasant to use, and probably will extend the life of the furnace beyond what it would be if using coal. Fortine gets its pellets from a plant in Sandpoint, Idaho, and the price includes a $20 a ton transportation charge.

The savings by local schools in converting to pellet burners has not been lost on the larger institutions. Both the University of Montana in Missoula and Montana State University in Bozeman are considering conversion of their heating plants to burn pellets. Montana State University estimates it could save at least $250,000 a year in fuel costs by switching from natural gas to wood pellets.

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